In Transit Temperature Relationships of Two Shipping Containers Loaded with Mangoes

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ABSTRACT

Thermocouples were placed at various positions in two shipping containers loaded with mangoes. The data indicate that return air temperature (RAT) accurately estimates pulp or pallet air temperature when fruit respiration is not elevated. However, RAT underestimates pulp or pallet air temperature when fruit pulp temperatures indicate elevated fruit respiration. Temperature differences signify poor air circulation in the pallets at the door-end of containers, and a reduction in cooling efficiency with pallet height. The effect thereof (temperature increases) is apparently accentuated when fruit respiration is elevated. It is concluded that in the absence of enhanced fruit respiration, RAT's can be used to manage air and pulp temperatures. It is recommended that measures to avoid situations which may effect enhanced fruit respiration should be taken in shipping mangoes to Europe. These include the adherence to transit temperature specifications, the avoidance of delays in the placement of fruit in cold storage after harvest, and the evasion of situations during transit which might effect a rise in fruit temperature.

INTRODUCTION

Delivery air temperature of a stack of containers and return air temperature of individual containers are recorded on vessels carrying mangoes from South Africa to Europe. Temperature management involves manipulation of the delivery air temperatures. In mango, container temperatures have been managed for many years despite there not being clarity on the relationships existing between air or pulp temperature and delivery or return air temperature.

The aim of the present study was to ascertain the relationships between internal container temperatures (pallet air or fruit pulp temperature) and delivery or return air temperature.

MATERIALS AND METHODS

A Grant Squirrel temperature recorder was placed in a container on each of two vessels at the time of loading. The containers were loaded with mangoes procured from different locations in the Tzaneen region. The specified tempera-

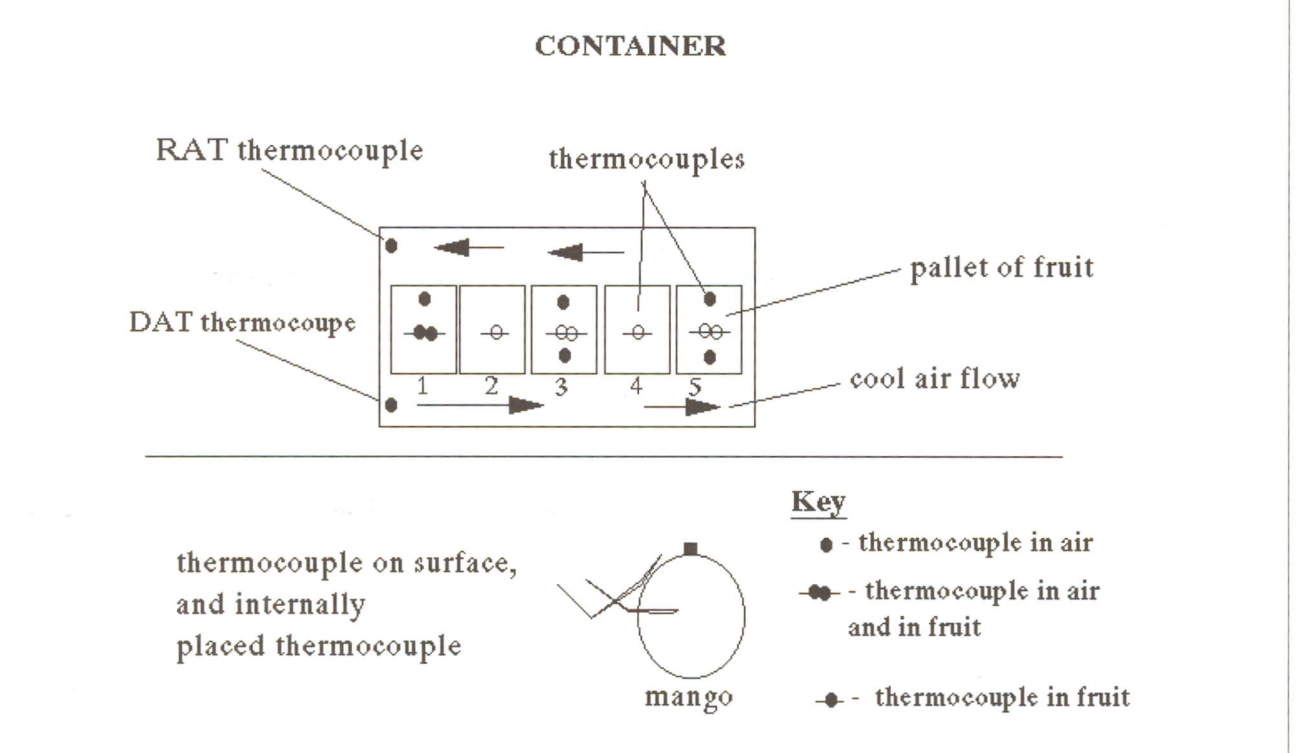

Fig. 1 *Thermocouple placement in the containers.*

ture was 8°C. The placement of the 15 thermocouples and of the temperature recorder was identical in each instance. Fig. 1 shows the locations of the thermocouples. The thermocouples were placed in and/or on fruits in inner central cartons (vertical core) located at various heights within the pallets. The "low" thermocouples were placed in the carton row just above the lowest carton row. The mid-thermocouples were placed in the central row. The "high" thermocouples were placed in the row immediately beneath the top carton row in the pallet. Where "fruit surface" air temperature and pulp temperature were recorded, both temperatures were taken from the same fruits. Thermocouples were stuck to the surface of certain fruits, and were inserted to a depth of 2.5 to 3 cm in the same fruits (see Fig. 1). Thermocouples were placed in five adjacent pallets on one side of the container. One thermocouple was placed at the point at which air was extracted from the container (to measure return air temperature - RAT) and one was placed at the position of air entry into the container (to measure delivery air temperature - DAT).

Temperature was logged every six hours from the time of departure until that of arrival in Europe. The first container was loaded with Keitt and Sensation fruits (Container 1), and the second container was loaded with Keitt fruits (Container 2).

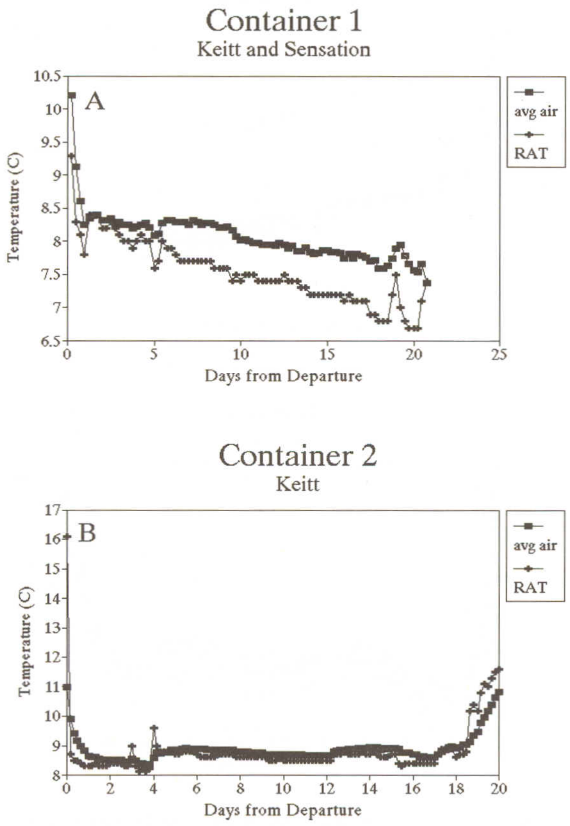

Fig. 2 *Average pallet air temperature in relation to return air temperature (RAT).*

RESULTS AND DISCUSSION

Figs. 2A and 2B show average pallet air temperature in relation to return air temperature (RAT). In Container 1, temperature generally decreased (as a result of temperature management procedures). RAT was less than average air temperature. The difference in temperature increased

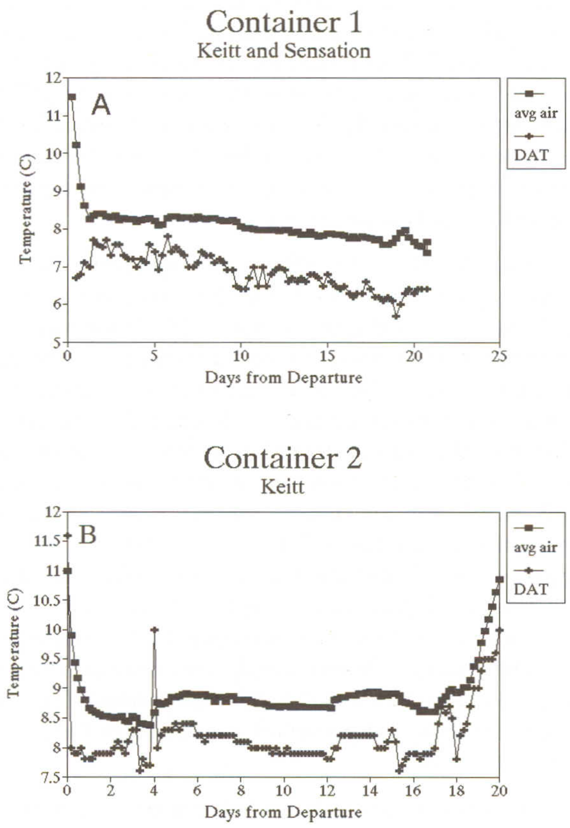

Fig. 3 *Average pallet air temperature in relation to delivery air temperature (DAT).*

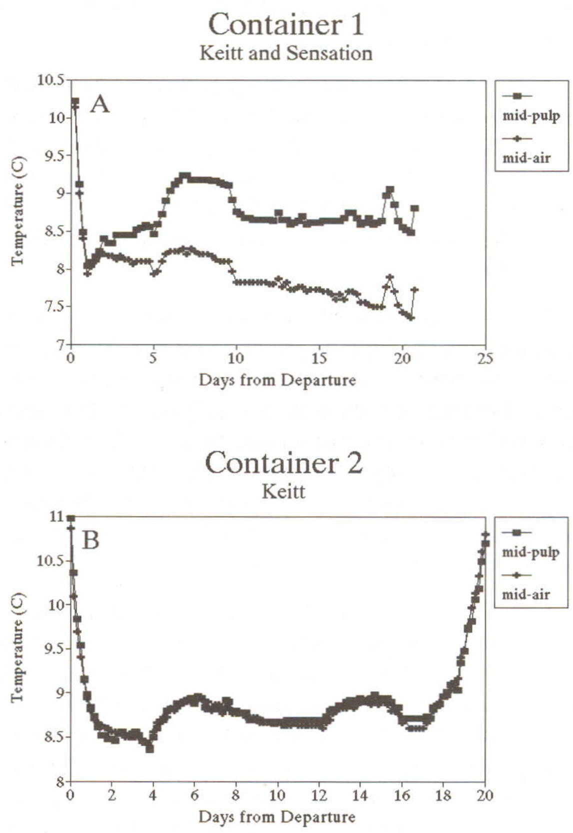

Fig. 4 *Average temperature of the thermocouples on the fruits in the mid-carton row and average pulp temperature.*

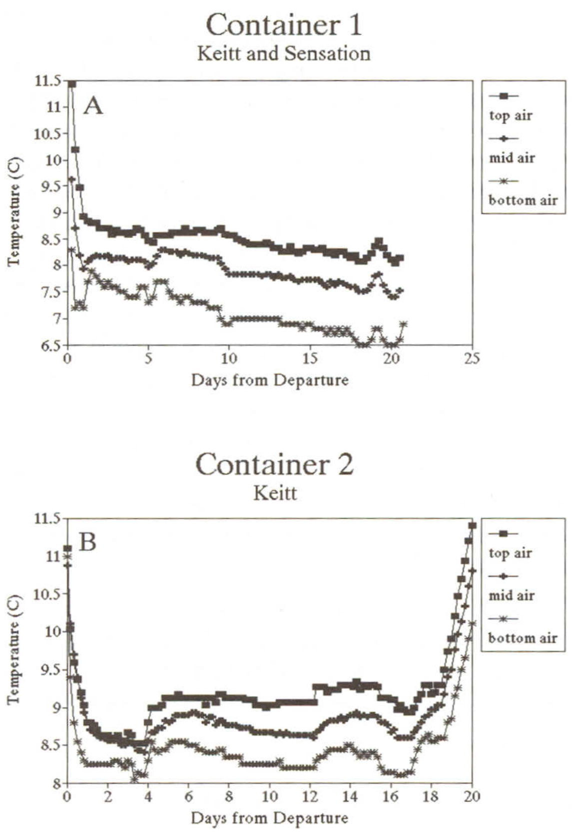

Fig. 5 *Average temperature of the air-thermocouples at the various heights in the pallets.*

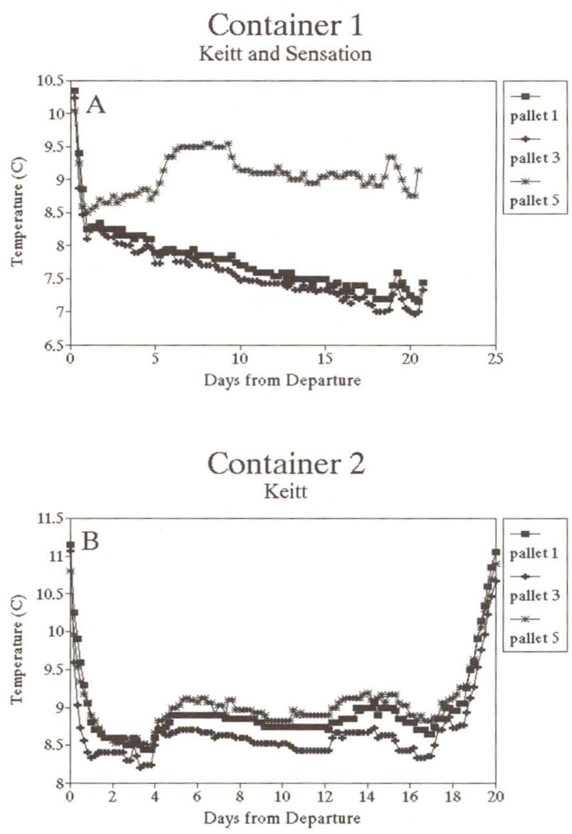

Fig. 6 *Average temperature of the air-thermocouples in Pallets 1, 3 and 5.*

slightly with time and averaged 0.53°C. In Container 2, temperature during the voyage was relatively constant. RAT and average air temperature differed only slightly throughout the sea voyage.

Figs. 3A and 3B show average pallet air temperature in relation to delivery air temperature (DAT). In Containers 1 and 2, DAT was less than average air temperature. In Container 1, the difference in temperature increased slightly with time and averaged 1.23°C. In Container 2, the difference in temperature was relatively constant over time, and averaged 0.7°C.

Figs. 4A and 4B show average temperature of the thermocouples on the fruits in the mid-carton row and average pulp temperature. In Container 1, pulp temperature exceeded average air temperature at all stages. This indicates elevated fruit respiration during transit. The difference in temperature increased slightly with time and averaged 0.79°C. In Container 2, pulp and average air temperature were not elevated and differed slightly, which indicates that fruit respiration was not elevated.

Figs. 5A and 5B respectively show average temperature of the air-thermocouples at the various heights in the pallets. In Containers 1 and 2, air temperature increased with pallet height. This indicates a reduction in cooling efficiency with height. The differences in average temperature in relation to pallet height remained relatively constant. In Container 1 the difference between the "high" and "low" thermocouples averaged 1.4°C. In Container 2, this difference averaged 0.72°C.

Figs. 6A and 6B respectively show average temperature of the air-thermocouples in Pallets 1, 3 and 5. In Container 1, air temperature in Pallets 1 and 3 differed very little. Air temperature in Pallet 5 was substantially greater than that in Pallets 1 and 3. This difference increased with time due to the general reduction in temperature of Pallets 1 and 3. The difference averaged 1.4°C. In Container 2, the differences in air temperature between Pallets 1, 3 and 5 were slight. However, the temperature of the air in Pallet 5 was generally greatest throughout the voyage.

Figs. 7A, 7B, 7C, 8A, 8B and 8C respectively show pulp temperature in relation to average air temperature in Pallets 1, 3 and 5 in Containers 1 and 2. In Container 1, pulp temperature substantially exceeded average air temperature in Pallets 1 and 3. The difference in Pallet 5 was slight. The variations in pulp temperature with time indicate changes in fruit respiration rate. The marked differences between pulp and air temperature indicate elevated fruit respiration as well as efficient air cooling (Pallets 1 and 3). Elevated temperatures and the absence of a difference (Pallet 5) signifies inefficient cooling due to poor cool air circulation. In Container 2, pulp and average air temperature differed little and were not elevated, indicating relatively low levels of fruit respiration. However, pulp and air temperature were greatest and increased in Pallet 5. This indicates less inefficient air cooling and poorer air circulation in Pallet 5 than in Pallets 1 and 3.

It is noteworthy that air and pulp temperatures were high (well above the specified temperature of 8°C) immediately after vessel departure. This signifies that the fruit were exposed to increased temperatures prior to vessel departure.

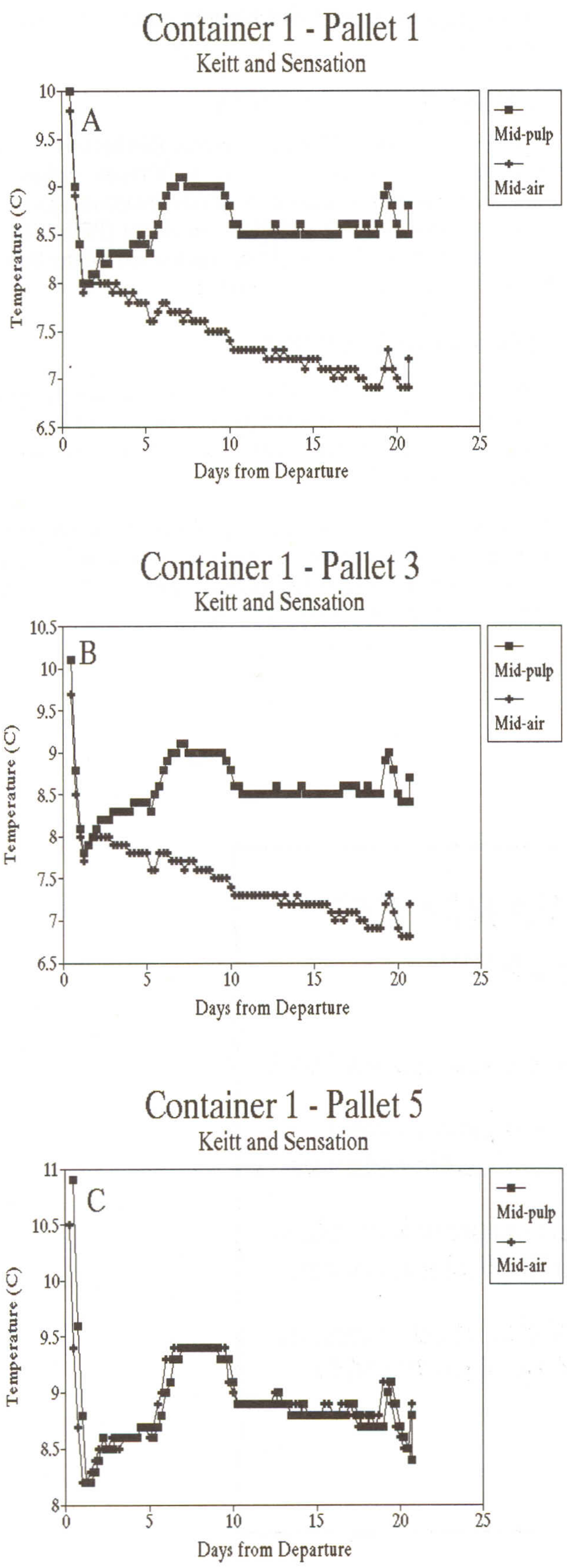

Fig. 7 *Pulp temperature in relation to average air temperature in Pallets 1, 3 and 5 of Container 1.*

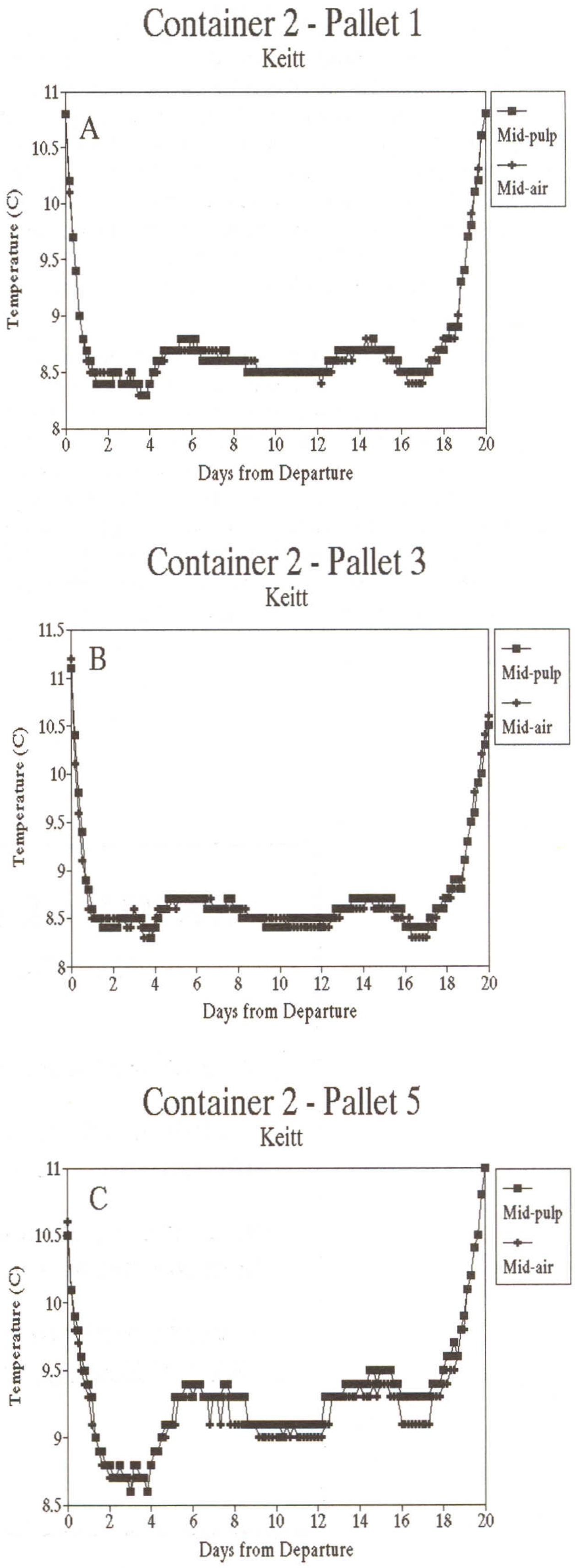

Fig. 8 *Pulp temperature in relation to average air temperature in Pallets 1, 3 and 5 of Container 2.*

CONCLUSIONS

The results clearly indicated that when respiration associated with fruit ripening is elevated, return air temperature (RAT) underestimates average pulp or pallet air temperature. However, when fruit respiration is not elevated the data plainly indicate that RAT accurately estimates pallet air or pulp temperature. The data also disclose that cool air circulation in the pallets at door-end of the container is poor, and that cooling efficiency in the upper cartons in the pallet is reduced. Furthermore, it would appear that the effect thereof (increases in temperature) is accentuated when fruit respiration is elevated.

In light of the foregoing results, it might be stated that in the absence of active fruit respiration, RAT's can be used to manage the temperature of fruit and air in containers. However, when fruit respiration is elevated, the use of RAT's to objectively manage pulp and pallet air temperature is questionable. Measures to avoid events which might effect elevated fruit respiration should therefore be taken. These include the adherence to transit temperature specifications, the avoidance of delays in the placement of fruit in cold storage after harvest (Oosthuyse, 1992, 1994), and the evasion of situations during transit (when the fruit are transferred, for example) which might cause a rise in fruit temperature.

ACKNOWLEDGEMENTS

Thanks are due to Henri Finnemore (SAMGA) for his assistance. Thanks are also due to Claude Tabanelli (Tzaneen Fruit Packers), Louis Aukamp (Intertrading), Bernard Henning (PPECB) and Pieter Hoekstra (PPECB) for their contributions. This study was sponsored by the South African Mango Growers' Association.

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